Tubular SOFC with Deposited Nanoscale YSZ Electrolyte

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NexTech's Mission

Our mission is to manufacture value-added ceramic materials for the electronic, energy, automotive, aerospace and medical industries, through the development and implementation of advanced powder synthesis and ceramic fabrication technologies.

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NexTech's Product Lines

Product Line	Products	Description
Solid Electrolytes	YSZ CeO_2 BYO BiCuVOx La-gallate	A range of nanoscale and conventionally prepared powders and dispersions formulated for specific applications - solid oxide fuel cells, oxygen generation and separation systems, membrane reactors
Catalysts	CeO_2 CeO_2-ZrO_2 Custom	Formulated nanoscale oxide powders and dispersions for automotive and fuel cell applications - CO, NOx, SOx reduction
Ferroelectrics	PZT PMN $BaTiO_3$	Formulated sub-micron and nanoscale oxide powders and dispersions for a variety of uses

Tubular SOFC with Deposited Nanoscale YSZ Electrolyte

- **DOE Grant Number:** DE-FG02-97ER82443.A001
- **Period of Performance:** 9/97 - 3/98 (Phase I)
  3/98 - 3/00 (Phase II)
- **Collaborating Partner:** Siemens-Westinghouse
- **Objective:** Develop a low-cost YSZ membrane fabrication process to replace electrochemical vapor deposition in Siemens-Westinghouse's tubular SOFC
- **Approach:** Deposition of dense YSZ films from colloidal suspensions, followed by sintering

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Nanoscale YSZ Electrolyte

Process Development Requirements

- Dense, crack-free YSZ Film of >20 microns thickness
- No effect on morphology of underlying LSM cathode
- Maximum sintering temperature less than 1300^{o}C
  - no reaction of LSM and YSZ (no $La_2Zr_2O_7$ formation)
  - no diffusion of Mn from LSM substrate into YSZ film
- Deposited YSZ film must be compatible with subsequent anode deposition (direct replacement to EVD)

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Nanoscale YSZ Electrolyte

Technical Approach

- **Synthesis of nanoscale YSZ suspensions**
  - **crystallite size: 5-10 nm**
  - **low sintering temperatures (1200-1300^{o}C)**
- **Preparation of dispersed YSZ suspensions**
  - **aqueous or non-aqueous solvent systems**
  - **dispersion needed for high green density films**
- **YSZ film deposition by dip-coating or spray coating**
- **Sintering to high density and crack-free YSZ films**

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NexTech's Hydrothermal Synthesis Process

FEED PREPARATION

Metal Salts, Alkali, Coprecipitation

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HYDROTHERMAL TREATMENT

Temperature < 300°C
Pressure < 15 MPa
Batch or Continuous

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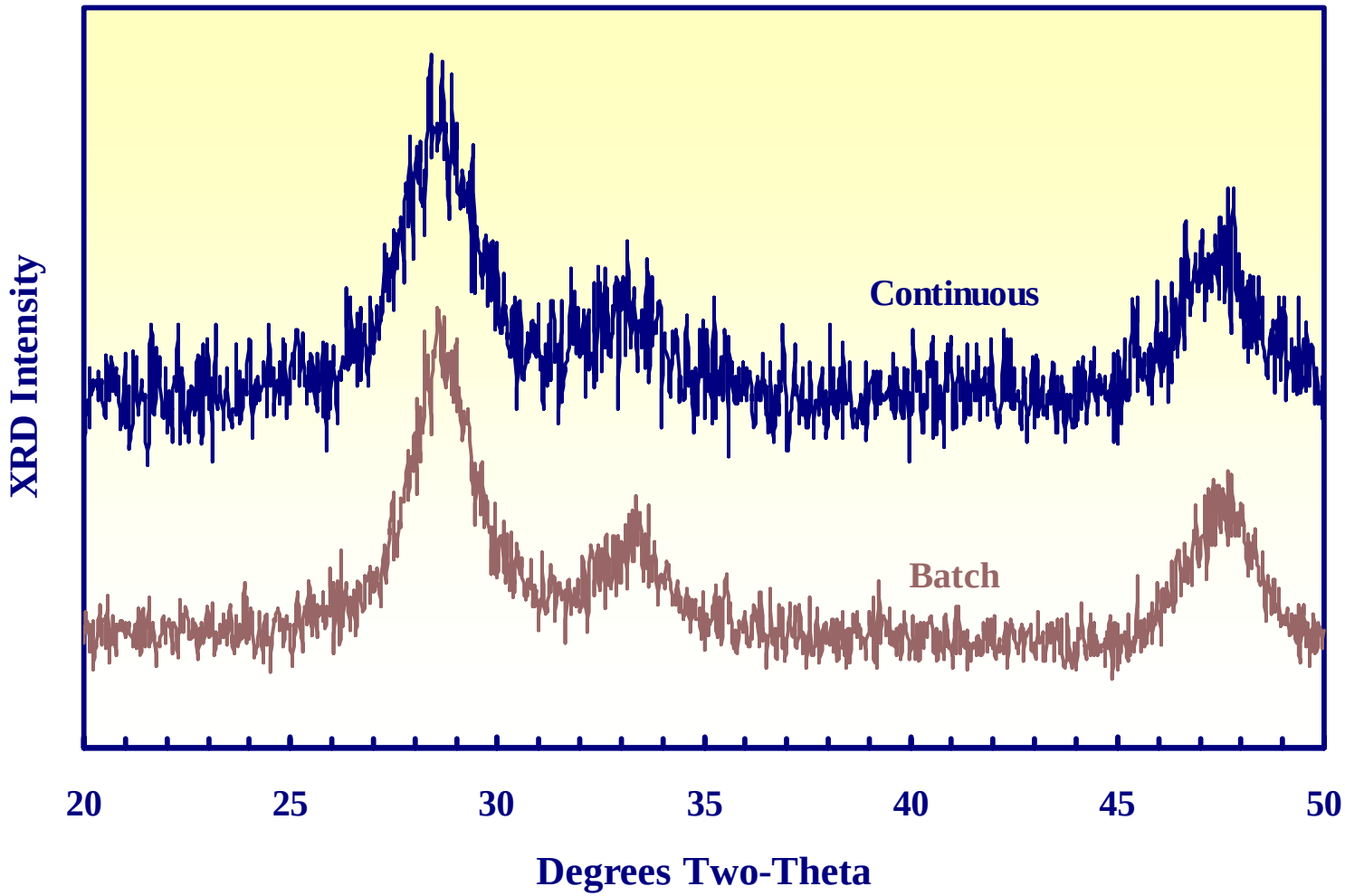
PRODUCT COLLECTION

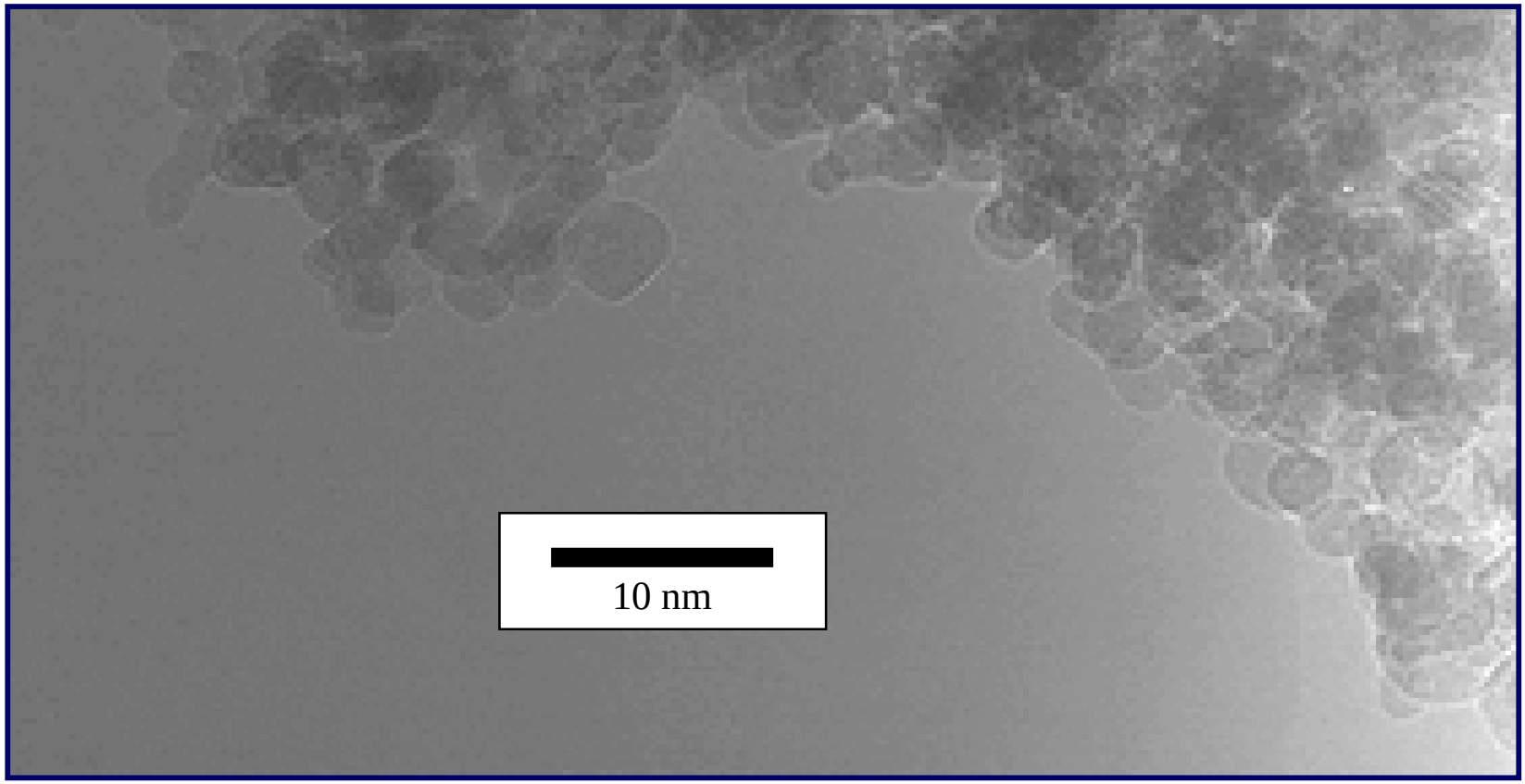
Dewatering, Desalting, Dispersion or Drying

1-kg/hr Continuous Nanoscale Powder Production

Scale-Up of YSZ Synthesis



Nanoscale YSZ Crystallites



Dispersion of Nanoscale Powders

- **Inevitability of Agglomeration**
  - Crystal size (TEM): 5-10 nm
  - Measured particle size: 500-1000 nm
- **Importance of Dispersion**
  - Colloidal deposition processes
  - Achieving high green densities
  - Minimizing sintering shrinkage
- **Dispersion Techniques**
  - pH control
  - Organic additives (dispersants)
  - Non-aqueous solvents

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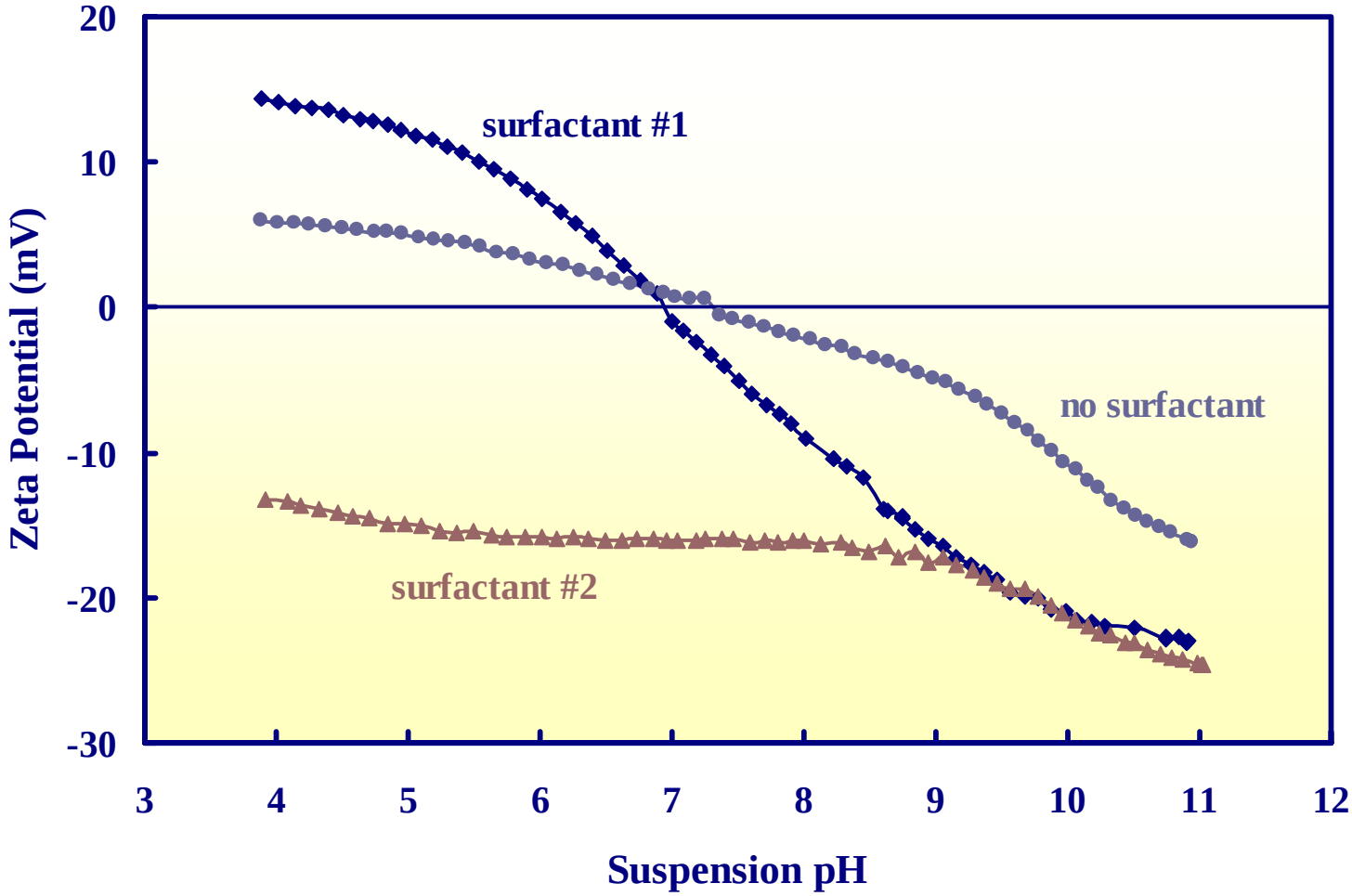
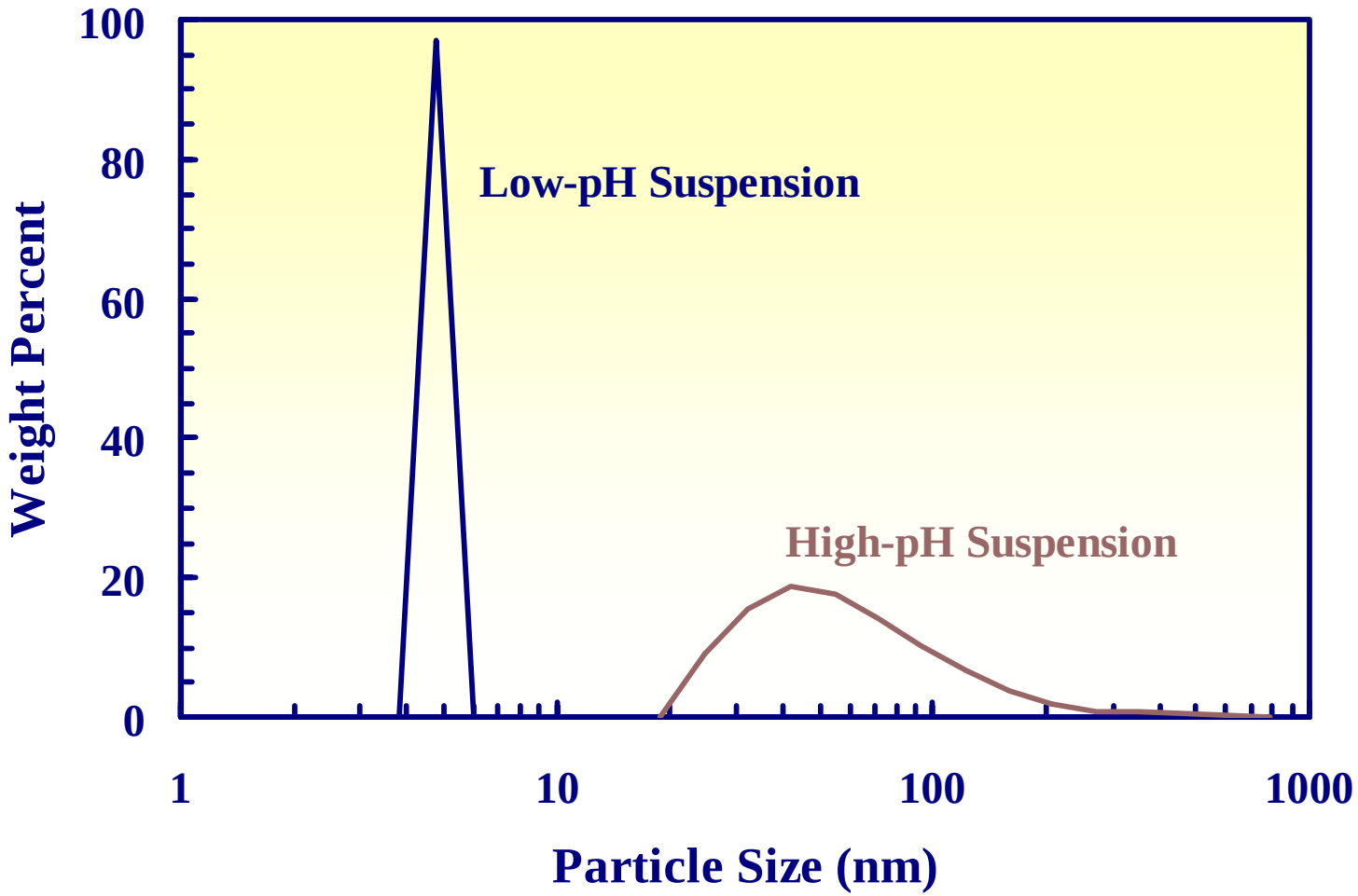
Zeta Potential Measurements (Hydrothermal YSZ Product)

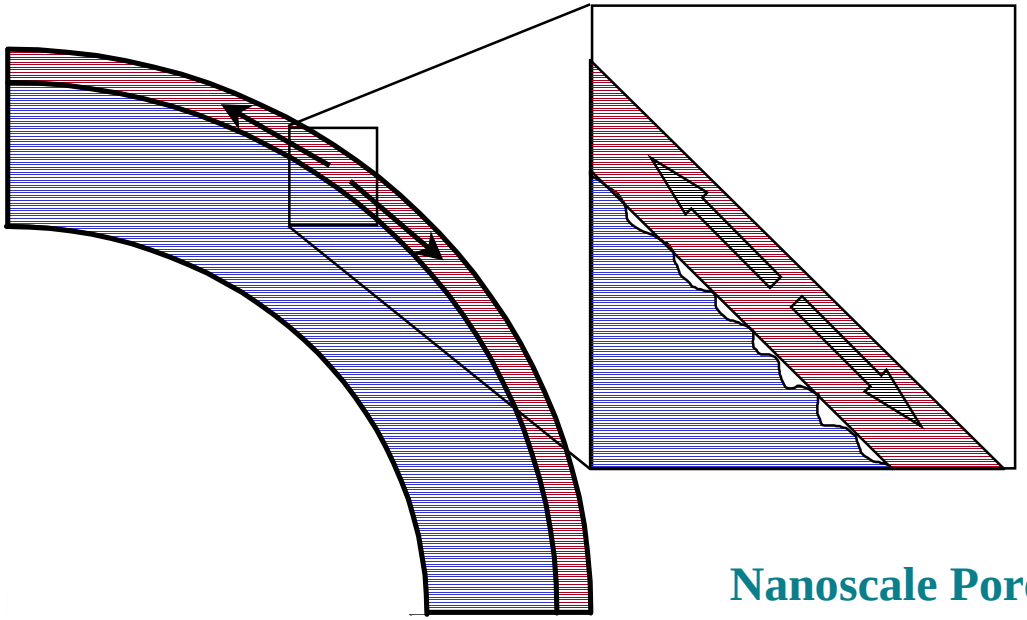


Dispersed YSZ in Suspensions



Tensile Stresses During Drying and Sintering

Rigid Substrate Creates Tensile Stresses in Drying and Sintering Films

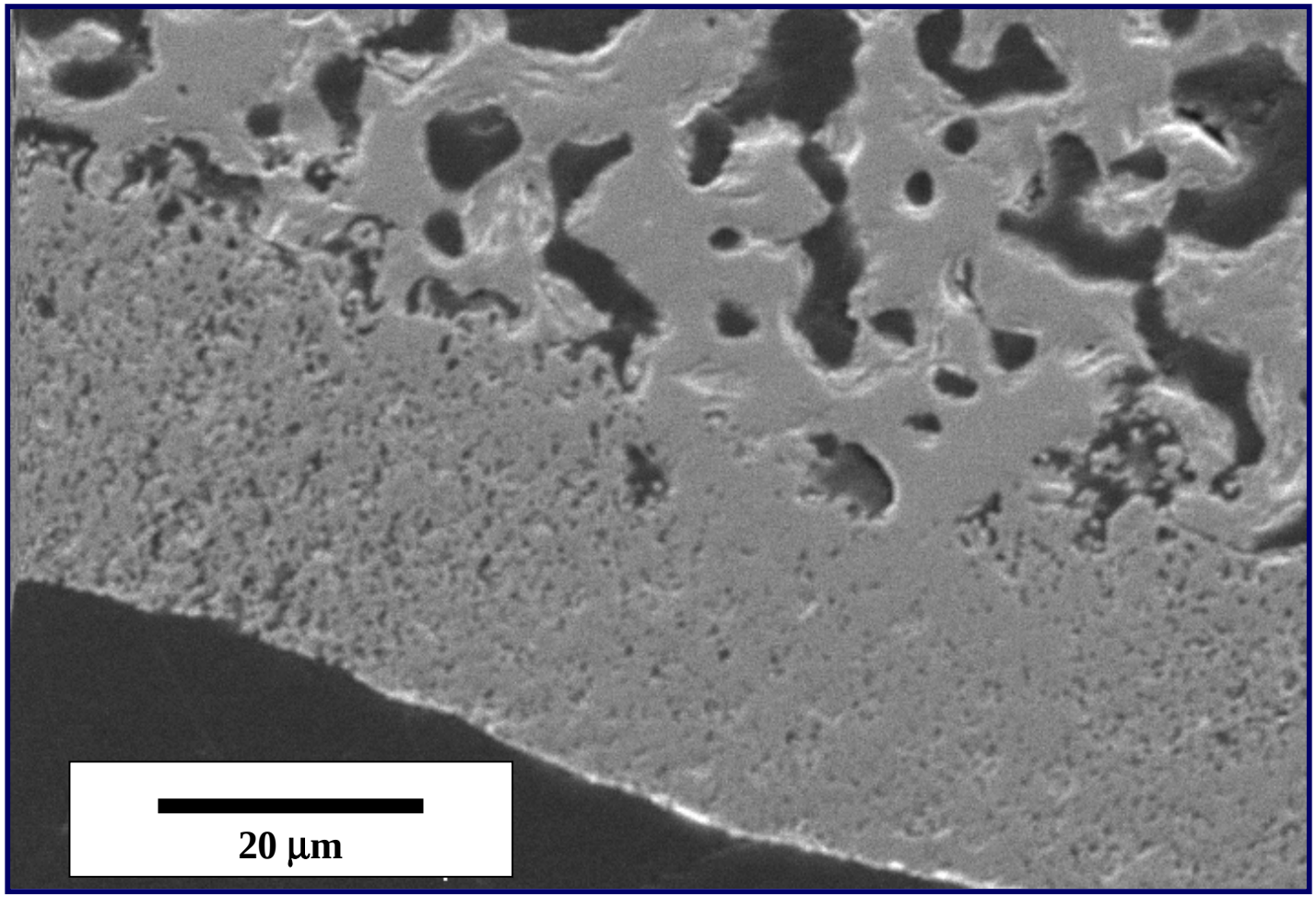


Porous Substrate Creates Unsupported Regions of Intense Stress in Coating

Nanoscale Porosity in Drying Film Creates Extremely High Capillary Tensile Stresses

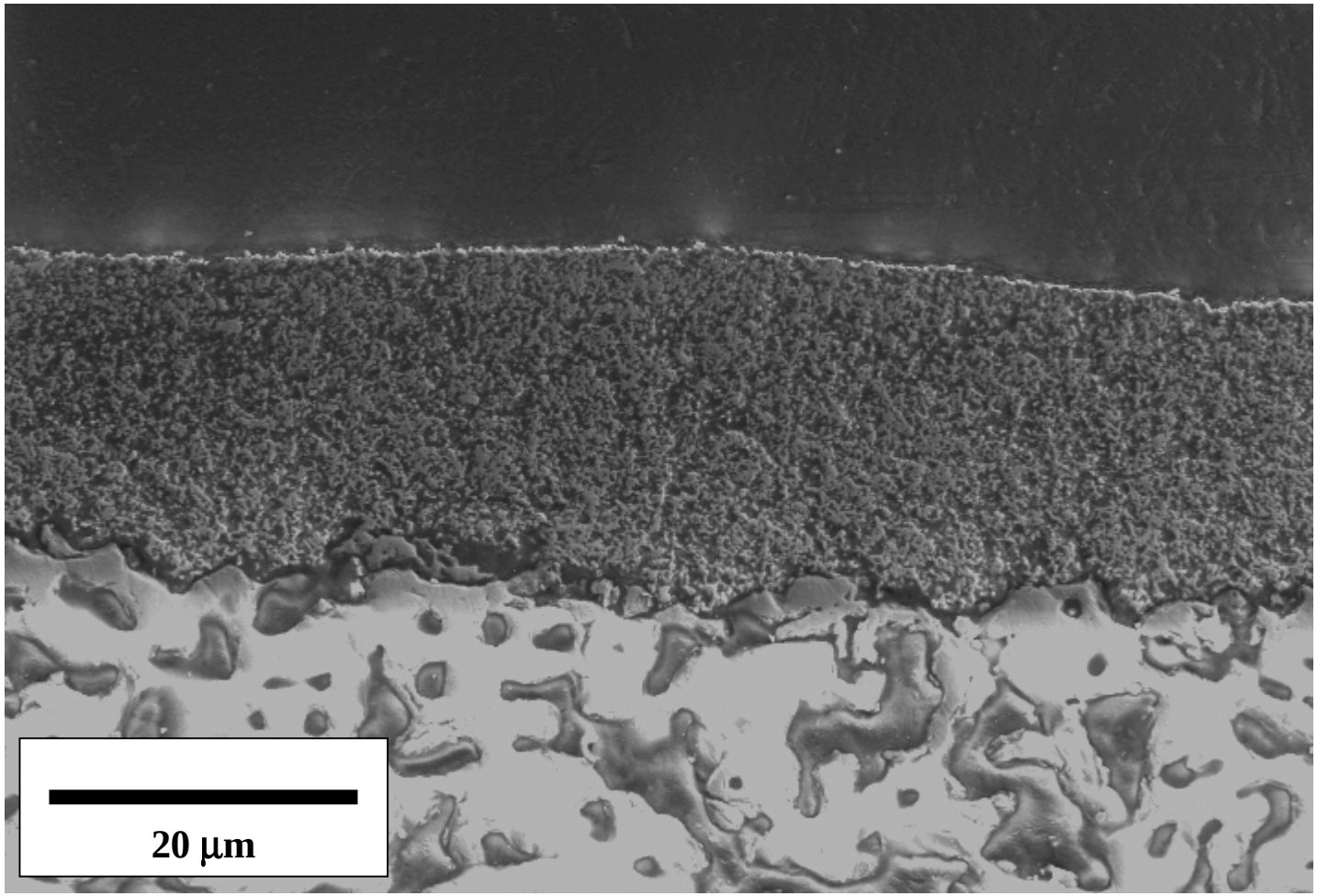
YSZ Film From Non-Aqueous Suspension

Sintered at 1300°C, 1 hour



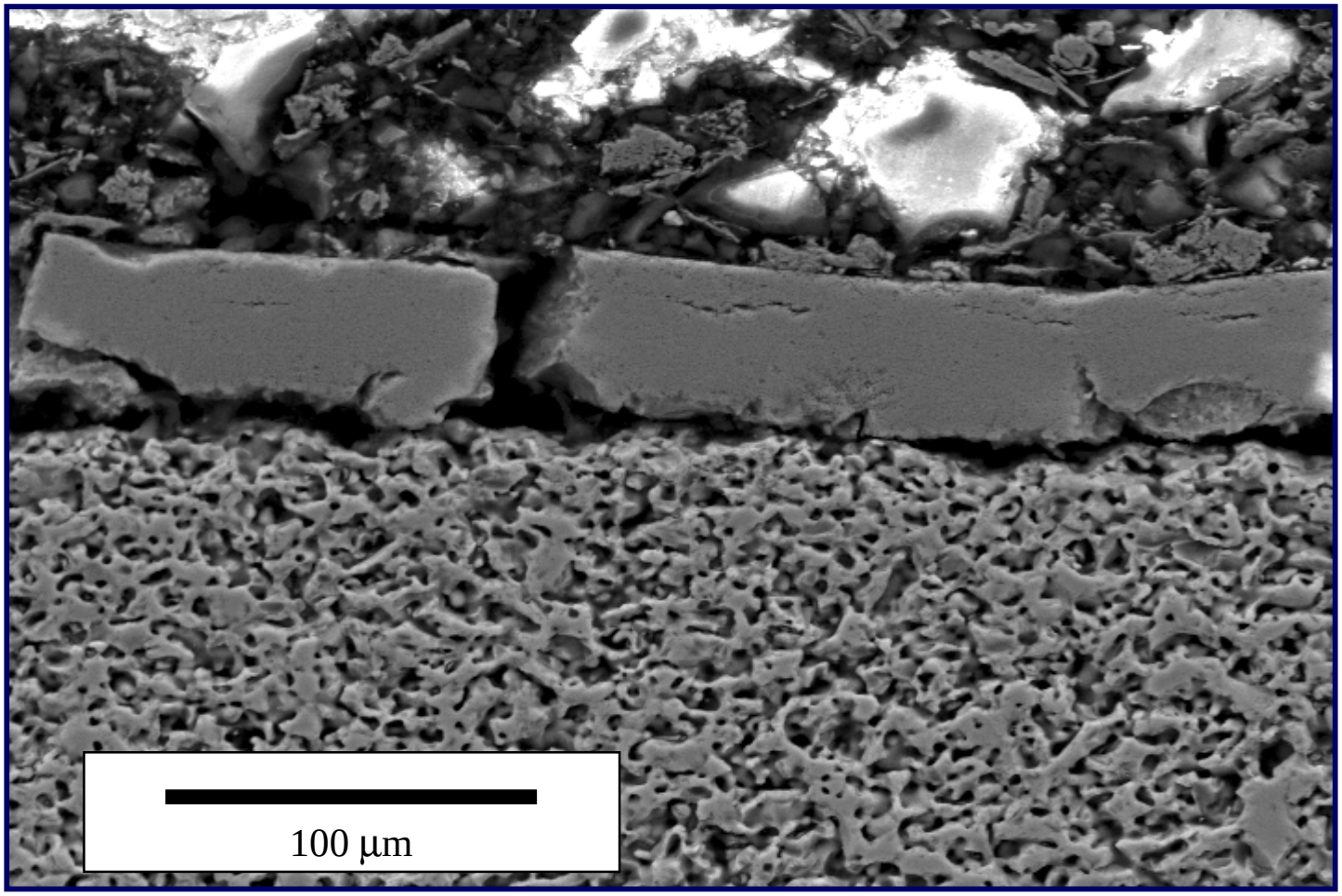
YSZ Film From Aqueous Suspension

Sintered at 1300°C, 1 hour



Cracking Resulting From Sintering Stresses

Aqueous Suspension, Sintered at 1300°C, 1 hour



Summary of Progress

- Synthesis and dispersion processes established for nanoscale YSZ suspenions.
- Methods identified to control rheology of aqueous suspensions.
- Aqueous deposition processes established for producing crack-free YSZ films.
- Ongoing work focuses on increasing packing density to improve sintered density.